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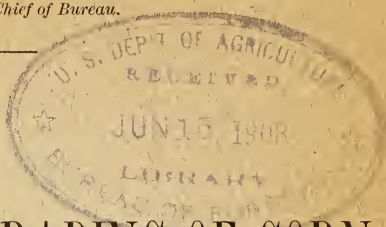
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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN No. 41.

B. T. GALLOWAY, *Chief of Bureau.*



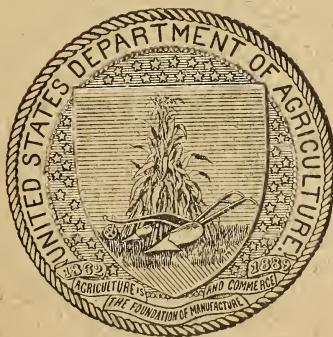
# THE COMMERCIAL GRADING OF CORN.

BY

CARL S. SCOFIELD,  
EXPERT, GRAIN INVESTIGATIONS.

BOTANICAL INVESTIGATIONS AND EXPERIMENTS

ISSUED JUNE 13, 1903.



WASHINGTON:  
GOVERNMENT PRINTING OFFICE.  
1903.

## BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

The Bureau of Plant Industry, which was organized July 1, 1901, includes Vegetable Pathological and Physiological Investigations, Botanical Investigations and Experiments, Grass and Forage Plant Investigations, Pomological Investigations, and Experimental Gardens and Grounds, all of which were formerly separate Divisions, and also Seed and Plant Introduction and Distribution, the Arlington Experimental Farm, Tea Culture Investigations, and Domestic Sugar Investigations.

Beginning with the date of organization of the Bureau, the several series of Bulletins of the various Divisions were discontinued, and all are now published as one series of the Bureau. A list of the Bulletins issued in the present series follows.

Attention is directed to the fact that "the serial, scientific, and technical publications of the United States Department of Agriculture are not for general distribution. All copies not required for official use are by law turned over to the Superintendent of Documents, who is empowered to sell them at cost." All applications for such publications should, therefore, be made to the Superintendent of Documents, Union Building, Washington, D. C.

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[Continued on p. 3 of cover.]

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B. T. GALLOWAY, *Chief of Bureau.*

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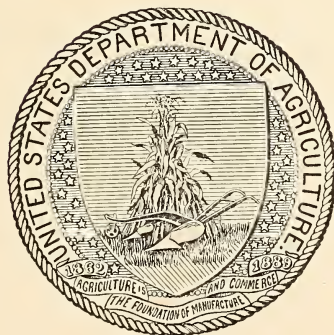
CARL S. SCOFIELD,  
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## BUREAU OF PLANT INDUSTRY.

B. T. GALLOWAY, *Chief of Bureau.*

### BOTANICAL INVESTIGATIONS AND EXPERIMENTS.

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## LETTER OF TRANSMITTAL

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U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF PLANT INDUSTRY,  
OFFICE OF THE CHIEF,  
*Washington, D. C., May 11, 1903.*

SIR: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 41 of the series of this Bureau, the accompanying paper entitled "The Commercial Grading of Corn." This paper was prepared by Mr. Carl S. Scofield, an expert of this Bureau, and has been submitted by the Botanist with a view to publication.

The four half-tone illustrations are essential for the purposes of this bulletin.

Respectfully,

B. T. GALLOWAY,  
*Chief of Bureau.*

Hon. JAMES WILSON,  
*Secretary of Agriculture.*





## PREFACE.

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For the past two years the Department of Agriculture has been investigating, in cooperation with the chief grain inspectors of the country, the systems of grain inspection in use in the various grain markets of the United States, in order to ascertain how these systems might be improved and made more useful to agricultural and commercial interests. The investigation has been prosecuted by Mr. C. S. Scofield under the direction of the Botanist, and the present report, covering the subject of corn, is the first to be presented for publication.

A difference of 2 per cent in the moisture of a shipload of corn may determine whether it will arrive at its destination in a sound condition or be seriously damaged. At present the only means which an inspector uses to determine this difference in moisture is his sense of touch, never aided or corrected by any actual measurement of the moisture.

Upon the request of the Botanist, the Chief of the Bureau of Chemistry conducted a series of moisture-determination experiments upon samples of corn furnished him, and fixed upon a form of apparatus suitable for measuring the moisture content of grain. With this apparatus a large series of moisture determinations has been made in the Botanical Laboratory on samples of corn secured from various markets. Based upon the results of these experiments, this report is now published in order to show to the commercial organizations how their inspection may be made more nearly uniform and how both the buyer and the seller may be benefited through the possession of a more exact description of their goods than can be secured by existing methods.

FREDERICK V. COVILLE,  
*Botanist.*

OFFICE OF THE BOTANIST,  
*Washington, D. C., May 1, 1903.*



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## THE COMMERCIAL GRADING OF CORN.

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### INTRODUCTION.

The business of buying and selling grain is one of enormous importance in this country. The production of breadstuffs is not the only thing to be considered in supplying the world with food. It is necessary that the raw material be moved to the points where it is needed and in most cases it must be milled before it is consumed.

The business of moving this grain from producer to manufacturer or consumer has been developed to a high degree. There are in nearly all our larger cities, particularly in those through which grain passes on its way to the consumer, either domestic or foreign, trade organizations whose members deal either wholly or partly in grain. These organizations are important to the producer as well as to the consumer, since they furnish the means for easy communication between the two and tend to prevent acute conditions of scarcity or congestion of material.

These organizations have adopted certain rules of trade which aim to permit their members to transact the largest amount of business with the least expense and friction. They have among other things established rules governing the classification and grading of the grain which they handle and the inspection of it, and providing for its weighing and registration.

These classes and grades of grain have been established to facilitate trade and as far as possible to dispense with the cumbersome method of dealing by sample. In some markets the inspection and grading have been developed to such a degree and work so satisfactorily that grain which is deliverable on contract is never shown by sample. The dealers depend wholly upon the honesty and efficiency of their inspection departments. In other markets this is not the case. The purchases, at least those made for consumption or manufacture in the latter markets, are made on the basis of sample and frequently regardless of the grade assigned by the inspection department.

It is customary for the trade organization in each market to establish for each kind of grain what is known as the "contract grade."

This grade is usually, though not always, the one of which there is the largest quantity handled at that market. Practically all deals made on contract or for future delivery are on the basis of this contract grade, and it is the price of this grade that is given in the market quotations.

The determination of what may or may not be delivered as contract grade or any other grade is left to the inspection department, which acts as arbiter, guided by the general rules or customs of the market.

### INSPECTION DEPARTMENTS.

Inspection departments are in most cases managed by the trade organization, independent of any outside control either on the part of the consumer on the one hand or of the producer on the other. However, in five States the grain-inspection departments operating therein are under the control of the State, either through a board of railway and warehouse commissioners or through a special commission.

The question as to how these inspection departments should be controlled is a local one and of relatively small importance. As a rule they are supported by fees for services rendered, and are presumably composed of efficient and disinterested men. What these departments need more than a change in or uniformity of control is a greater uniformity in methods of work and in results. To attain this they must have more adequate equipment. They must have available such apparatus as is necessary to educate the judgment of the inspectors for general work and to determine accurately all cases of doubt or appeal.

The cost of maintaining grain inspection is a small item when the interests involved are considered. The charge varies in different markets from about 25 cents to 75 cents per carload or per 1,000 bushels, or from less than one-quarter of a mill to three-quarters of a mill per bushel. A slight error in judgment on the part of an inspector may make a difference of a grade in any cargo, which, under normal conditions, means a difference of 2 or 3 cents a bushel, while at other times, as in case of a "corner," the difference may be much greater. Thus, while the inspection costs, say, 50 cents, a wrong grading might mean a difference of \$25 on a carload. Relatively, therefore, the cost of grain inspection is an inconsiderable item.

### GRAIN GRADING.

Reduced to its simplest terms, the inspection and grading of grain consists in the examination of the various lots or cargoes to determine the uniformity of each and the assigning of them to the grades to which they belong. This would obviously be simple enough were the elements considered in grading all easily measured and defined, or were they reasonably distinct; but they are neither. The variations on different lots are frequently so slight that if a line is drawn which is to mark a



limit of a grade it is difficult to determine in cases close to this line whether they may be admitted or not. More than this, the qualities considered do not vary uniformly; for example, one lot of grain may be of very high quality in all respects but one, while another may be good in all but some other one point, and still another may be mediocre in all respects. For some purposes the first lot might be worth quite as much as if it had no defect, while for other purposes it would be worth less than the other lots merely on this account. It has therefore been difficult to make rules governing grades or to state grade requirements in a way that is definite and satisfactory. The men who have made these rules and definitions for grades have met this difficulty by resorting to the use of indefinite terms and obscure phrases, leaving the responsibility for their interpretation almost entirely with the inspector.

Following are the rules for grading corn recently recommended by the Chief Grain Inspectors' National Association for adoption by the trade organizations and commissions which control the inspection departments represented by these chiefs:

## CORN.

*No. 1 Yellow Corn* shall be pure yellow corn, sound, plump, dry, sweet, and clean.

*No. 2 Yellow Corn* shall be 95 per cent yellow corn, dry, sweet, and reasonably clean, but not sufficiently sound or plump for No. 1 Yellow.

*No. 3 Yellow Corn* shall be 95 per cent yellow corn, reasonably dry, reasonably clean, but not sufficiently sound and dry for No. 2 Yellow.

*No. 4 Yellow Corn* shall be 95 per cent yellow corn, not fit for a higher grade in consequence of being of poor quality, damp, musty, or dirty.

*No Grade Yellow Corn.* (See general rule.)

*No. 1 Mixed Corn* shall be mixed corn, sound, plump, dry, sweet, and clean.

*No. 2 Mixed Corn* shall be mixed corn, dry, sweet, and reasonably clean, but not sufficiently sound and plump for No. 1 Mixed.

*No. 3 Mixed Corn* shall be mixed corn, reasonably dry, reasonably clean, but not sufficiently sound and dry for No. 2 Mixed.

*No. 4 Mixed Corn* shall be mixed corn not fit for a higher grade in consequence of being of poor quality, damp, musty, or dirty.

*No Grade Mixed Corn.* (See general rule.)

*No. 1 White Corn* shall be pure white corn, sound, dry, plump, sweet, and clean.

*No. 2 White Corn* shall be 98 per cent white corn, dry, sweet, reasonably clean, but not sufficiently sound and plump for No. 1 White.

*No. 3 White Corn* shall be 98 per cent white corn, reasonably dry, reasonably clean, but not sufficiently sound and dry for No. 2 White.

*No. 4 White Corn* shall be 98 per cent white corn, not fit for a higher grade in consequence of being of poor quality, damp, musty, or dirty.

*No Grade White Corn.* (See general rule.)

*No Grade—General Rule.*—All grain of any kind and variety that is wet, hot, or in a heating condition, burned or smoky, contains weevil, or is for any reason unfit for warehousing, shall be classed and graded "No Grade."

These rules are considered as representing the latest commercial ideas on rule making for the grading of corn, and were proposed for



the purpose of securing uniformity of work by the various inspection departments.

Except for the percentage of color permissible in each of two of the classes, there is scarcely a term used in stating these grade requirements which does not give great latitude for personal interpretation. The terms "reasonably dry" and "reasonably clean" are too indefinite to stand alone as a basis for accurate work. The clause in grade No. 3 "but not sufficiently sound and dry for No. 2" is not especially lucid when investigation shows that the corresponding clause of grade No. 2 reads "but not sufficiently sound and plump for No. 1," while No. 1 requires that the corn shall be "sound," "dry," and "plump."

Having such indefinite standards to work to and being buffeted about by opposing interests vitally concerned in the decisions which he makes, it does not seem strange that the inspector should sometimes do inconsistent work, nor is it to be wondered at that the grading of similar lots of grain differs in different markets.

It is customary in most markets at the present time for the actual work of grading to be done on the railroad track or at the delivery spout of an elevator by a deputy inspector. This deputy must work rapidly, through all kinds of weather and light, in many cases without supervision, and nearly always without apparatus for deciding doubtful cases or means of having his judgment corrected in case of error. If his decision is not satisfactory to the interested parties, appeal may be taken or reinspection called for; but the deputy seldom knows directly the results of such appeal or reinspection, and still more rarely does he know the reason for the change, if one is made.

In some cases shipments from a market are sampled and the samples kept for a time at the main office of the inspection department, particularly in case of cargoes for export; but these samples are taken and kept more for purposes of identification and certification than to educate or correct the judgment of the deputy inspectors.

The movement of grain from one market to another in this country and from the various interior points to the coast ports for export involves, in the regular course of business, unless it is shipped directly through with its identity preserved, from three to six inspections on any given lot of grain. Where grain is handled wholly in bulk and where it must be transferred from cars to elevators, from elevators to boats, from boats to elevators, and again to cars, and possibly again to elevators before being finally delivered for manufacture or export, preserving its identity involves so much additional trouble and expense that it is not ordinarily done; nor would this be necessary were it possible to maintain a system of inspection and grading by which commercial grain could be accurately graded according to its commercial value.

Millers and other manufacturers of cereal products, as well as large

consumers of raw cereals, are forced by competition to learn the relative values of the various lots of grain offered for sale. Science has aided these men in determining the best kinds of grain for their various purposes and how they may be distinguished. These manufacturers and consumers are the men who actually and finally determine relative values in cereals, and the discriminations which they make and the elements which they consider in selecting their material should be the basis used by the grain inspectors in their work.

All grain is intended ultimately for consumption, and the number of times it may be bought and sold between the time of its production and consumption makes no change in this fact. The apprehension that uniform or accurate grading of grain may in any way interfere with extensive grain dealing, either actual or speculative, is entirely without foundation. On the other hand, such grading should help the trade by eliminating in a great measure one of the largest sources of misunderstanding and consequent loss, and would give to those who maintain such a system a decided advantage in the world's markets over those who do not.

#### DEFINITE GRADE STANDARDS.

One of the first needs of the grain trade in this country is to have the grade requirements accurately stated and the grade limits accurately defined. Grain grades, if they mean anything, mean definite relative values.

The chief trouble at present with this grading work is that the inspectors who have to pass upon and accept or reject the grain delivered for a certain grade have no definite standard for guidance—no means of knowing what the grade requirements really are. They have in most cases only their unaided judgment. An appeal from this judgment must go to a board of appeals or to the grain committee controlling the inspection department. In either case the deputy inspector has insufficient opportunity for checking up his work.

In view of the difficulties under which it is done, it is remarkable that the work of the various inspection departments in the commercial grading of grain is not even less successful and satisfactory than is now the case. Without favorable opportunities for educating their judgment, inspectors have nevertheless developed marked ability for determining both quality and condition of grain by actual commercial experience. As the inspector has almost no definite guide for his work, but must use his own unaided judgment, he should not be too severely criticized if the character of his work fluctuates from time to time, particularly since, as has already been stated, he is often called upon to pass his judgment very hurriedly and under adverse conditions of weather and light. In cases where grain is inspected and graded into elevators or for sale on track, an inspector, even one having

definitely in mind the supposed grade requirements, is often tempted to let a poor car into a grade if he knows there are some very good cars of that grade going in with it to even matters up. This, of course, works an injustice to the original shippers of the good cars, since the purchaser of the mixed lot can pay no more than the mixture is worth.

#### GRADE UNIFORMITY.

Our interstate or intermarket trade, as well as our foreign trade, urgently demands a system of grading which shall be uniform throughout the country, or at least for those markets handling the same kinds of grain. In fact, uniformity is at present of more commercial importance than any other one thing connected with grain inspection. This much-desired uniformity can not be attained until there is in use some definite understanding as to what essential qualities shall be considered in the grading of grain, and some definite rules adopted for measuring these qualities.

It is the purpose of this publication, in discussing the commercial grading of corn, to show what some of these essential elements are, something of their relative importance, how they may be measured simply, accurately, and speedily, and how the results may be stated in a way to show exact conditions. These results are expressed in figures, and the promulgation of satisfactory grade limitations is all that remains to secure uniform work, so far as the elements measured are concerned.

The late Mr. S. H. Stevens, the veteran flax inspector of the Chicago Board of Trade, developed such a method for his work, which is probably at the present time the most nearly satisfactory system of commercial grain inspection in existence.

In a report to the Chicago Board of Trade, under date of September 1, 1900, Mr. Stevens published the grade standards for flax adopted by the Board of Trade a year previous, with the statements that during the year of the operation of the definite rules "no suggestion of weakness or desired change has reached this office from any source," and "the flaxseed inspection committee, although in close touch with the department, has not been officially called for the correction of error during the year."

Following is the rule for the grade of No. 1 Northwestern flaxseed published by Mr. Stevens September 1, 1900:

*No. 1 Northwestern flaxseed.*—Flaxseed to grade Number One Northwestern shall be mature, sound, dry, and sweet. It shall be northern grown or have the usual characteristics thereof. *The maximum quantity of field, stack, storage, or other damaged seed intermixed shall not exceed twelve and one-half per cent.* The minimum weight shall be fifty-one (51) pounds to the measured bushel. <sup>a</sup>

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<sup>a</sup> The italics in the above rule do not occur in the original.



In this connection it is interesting to look at the rules in force under the Minnesota system of grain inspection just before and just after the publication of Mr. Stevens's report.

From Minnesota Grades, August 22, 1900:

*No. 1 Northwestern flaxseed.*—Flaxseed that is choice or prime, as also the same moderately intermixed with field damaged seed, dry, sweet, and free from mustiness, and having weight of not less than fifty pounds to the measured bushel of commercially pure seed, shall be No. 1 Northwestern flaxseed. <sup>a</sup>

From Minnesota Grades, August 31, 1901:

*No. 1 Northwestern flaxseed.*—Flaxseed to grade No. 1 Northwestern shall be mature, sound, dry, and sweet. It shall be northern grown. *The maximum quantity of field, stack, storage, or other damaged seed intermixed shall not exceed twelve and one-half (12½) per cent.* The minimum weight shall be fifty-one (51) pounds to the measured bushel of commercially pure seed. <sup>a</sup>

The investigations which have been made by the Department of Agriculture during the year past give good reason for believing that what has been found possible in flax is also possible for the cereal grains—corn, wheat, oats, barley, and rye.

It must be distinctly understood that the methods here outlined are not intended to be applied to every car or cargo of grain inspected. The rapidity with which the grain business is conducted makes it impracticable to use any method that requires any considerable time for each lot of grain. These methods, however, may be used as a check upon the work of the deputy inspectors, to educate their judgment, to prevent carelessness or dishonesty, and to give inspection departments a means of justifying the decisions which they make.

#### ESSENTIAL ELEMENTS IN GRADING CORN.

In grading commercial corn there are two classes of elements to be considered. First, those which indicate condition—moisture, percentage of moldy, rotten, or otherwise damaged kernels, and percentage of broken grains, dirt, and other foreign material; and second, those which indicate quality—color, plumpness, relative proportion of starchy to hard material, and relative size of germ. For present purposes there are four elements which are essential in determining the grade of a cargo of corn and which may, when necessary, be measured with reasonable accuracy and speed. These are (1) the moisture, (2) the percentage of colors in mixtures, (3) the percentage of damaged grains, and (4) the percentage of broken grains and dirt.

The relative importance of these elements varies under different conditions and with the different demands which the grain is used to supply. It is not to be understood that the four elements mentioned are all that should be considered in grading corn, but they are at least important and of such a nature that they may be accurately measured;

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<sup>a</sup> The italics in the above rules do not occur in the originals.

and having these four generally understood there is available a basis for uniformity which has not up to this time been offered to the trade.

### APPARATUS REQUIRED.

The apparatus required for measuring the elements mentioned above is as follows, the prices given being approximate:

One balance, with weights .....	\$33.00
One copper oven, or air-bath.....	12.00
One centigrade thermometer .....	1.25
One gas heater <sup>a</sup> .....	1.00
One metal sieve, with top and bottom .....	2.35
One coffee or spice mill.....	1.75
One set of aluminum pans, at 40 cents each, about .....	4.80
Miscellaneous apparatus .....	1.00
<hr/> Total estimated cost .....	<hr/> 57.15

The balance should be as accurate as possible, since the most important part of the work depends upon results obtained by its use. It should be sensitive to 10 milligrams or less. A very compact and satisfactory balance is shown in Pl. II, fig. 2.

The oven or air-bath (Pl. I) is simply a copper box covered with asbestos, having a large door and with two holes in the top, through one of which the thermometer is suspended. The bath contains a shelf upon which the pans of material may be placed during the drying operation. When an electric heater is used it may be placed inside, under the shelf. When gas is used the heater must be placed underneath the bath, where it is protected by the galvanized-iron box upon which the bath rests.

The thermometer is suspended through one of the holes in the top of the bath by means of a perforated cork in such a way that it may be read without opening the door. The temperature of the bath should be kept at about 102° to 105° C. (215° to 221° F.). This temperature may be readily controlled without any automatic device, as the operator is usually working near the apparatus and can give it his attention at any time.

When only electricity is conveniently available, a small electric heater may be used. The amount of heat may be controlled by means of an adjustable resistance coil outside of the air-bath. This electric heater has proved very satisfactory, and of course claims the advantage of less danger of fire. Wherever gas is available, however, it may be desirable to use it, as the heat thus obtained is rather cheaper and is somewhat more easily regulated.

The sieve used for determining the amount of broken material, dirt, and other foreign matter is a plain metal sieve having 5 strands to the inch. In other words, it is a wire screen having 25 square holes per square inch.

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<sup>a</sup>An electric heater, with resistance coil, would cost about \$11, bringing the total estimated cost up to \$67.15.

The mill for grinding (Pl. II, fig. 1) should be simple and strong and easily taken apart for cleaning. An extra set of burrs is also desirable, so that in case several samples need to be ground in close succession the burrs may be changed before they have warmed enough to heat the corn passing through.

The aluminum pans are 4 inches in diameter and about 1 inch deep and are used for holding the samples during the drying and weighing process.

In addition to the apparatus mentioned, there are also required some few additional articles, such as a brush, forceps, and a smooth spoon or spatula.

### METHODS OF DETERMINATION.

The methods of determining the four elements mentioned may be briefly described.

#### MOISTURE.

For determining the moisture a small sample of corn should be ground into a coarse meal. If the corn is ground too fine it becomes heated during the operation and there is a consequent and irregular loss of moisture. After grinding a definite quantity of the sample, it should be weighed out in one of the aluminum pans. The larger this quantity the less the percentage of error in weighing is likely to be. However, for quick work the sample must not be too large. Twenty or thirty grams has been found a convenient amount to use. This weighed quantity, which for convenience in reckoning should be an even weight, either 20 or 30 grams, is then placed in the air-bath, which has been previously heated to about  $102^{\circ}$  C. ( $215^{\circ}$  F.). This temperature is slightly above the boiling point of water and will quickly evaporate the moisture, and after subsequent weighing the percentage of loss may be determined. Theoretically the sample should be dried until repeated weighings would show no further decrease in weight, but for practical purposes, where the element of time required for making these determinations is important, a shorter time will suffice. It has been found by numerous experiments that the amount of moisture which a sample of coarsely ground meal will give up during two hours' drying at  $102^{\circ}$  to  $105^{\circ}$  C. ( $215^{\circ}$  to  $221^{\circ}$  F.) is about  $1\frac{1}{2}$  per cent less than the total amount of moisture contained, so that for commercial purposes two hours' drying at the above temperature will yield results from which the total moisture can be estimated with sufficient accuracy for general work. It is necessary, however, to extend this time to three hours on days when the atmosphere is especially damp. Whenever immediate results are not absolutely necessary, it is much safer and more satisfactory to dry the sample completely; that is, to dry it until repeated weighings show no further loss. This commonly requires twelve to sixteen hours. After



the samples have been dried they should be weighed again with all possible speed, as the meal readily absorbs moisture from the atmosphere upon being removed from the air-bath. It is best in all cases to make duplicate moisture determinations, as errors are likely to be made by even the most careful workman. These duplicates should be made from separate grindings of different portions of the sample. Where the results of the two determinations in the short-time drying differ by more than about 1 per cent a third determination should be made.

#### COLOR.

The percentage of color may be determined by simply counting out the number of kernels of each color in a fair average sample. At least 500 kernels should be used as a basis of reckoning.

#### DAMAGED GRAINS.

The percentage of damaged grains is determined by counting out the number in a fair average sample of at least 500 grains and reckoning the percentage of the number present. The damaged grain is considered to include all cob-rotten, bin-burnt, moldy, or otherwise unsound kernels.

#### BROKEN GRAINS AND DIRT.

This determination should be made on the basis of weights; that is, by weighing out a definite quantity of corn and separating by means of the sieve mentioned above and by subsequent hand picking, all broken grains, meal, dirt, chaff, and foreign material of whatever nature. This determination should be made on a reasonably large sample of corn—at least a kilogram (2.2 pounds). Where large scales are not at hand it is sometimes convenient to use the ordinary chondrometer or brass bucket employed in making the test weight per bushel of wheat, and the siftings and pickings may be weighed on the small balance used for the moisture work, and the percentage reckoned. The  $5\frac{1}{2}$ -inch chondrometer holds about 1,800 grams (or  $\frac{1}{2}$  pounds) of corn.

#### CLASSES AND GRADES OF CORN.

The bulk of the corn crop of the United States is of the kind known as dent corn. The grain trade recognizes three distinct classes of this kind of corn, based on color. There are, of course, other colors of dent corn, but practically all commercial corn may be classified into "yellow corn," "white corn," and "mixed corn." There is not at present any great degree of uniformity as to what shall constitute the color limits of these classes, but the general opinion seems to be that the following would be satisfactory:

1. Yellow corn; at least 95 per cent yellow.
2. White corn; at least 98 per cent white.
3. Mixed corn; all corn not included above.



Of each of these three classes of corn there are generally made four grade divisions, numbered one, two, three, and four, with the addition of a grade known as "Rejected," or "No grade." These grades are theoretically made on the basis of considering No. 1 as perfectly sound, perfectly clean, and dry enough to carry or store for an indefinite time. As a matter of fact, the grade No. 1 is seldom or never used as a commercial grade of corn. The grade No. 2 is generally allowed to contain a small amount of broken grains and foreign material and a few damaged grains, No. 3 a slightly increased amount, No. 4 a still larger amount, and the name "rejected" or "no grade" is applied to such corn as is unfit by reason of excessive moisture, dirt, or damage, to be admitted into the numbered grades.

The indefiniteness of the rules governing grades has made it difficult to compare grade requirements of different markets, and any changes found desirable from year to year for different conditions of weather and general quality have been made by different interpretations of the rules rather than by definite changes in the rules themselves. If, however, the methods outlined herewith are put into practice it would be possible to so state the grade requirements that they may be comprehended at a glance. For this purpose it is convenient to use a tabular statement like the following for showing the grade limits. This tabular statement is merely a way of showing in a condensed form the grade rules of a certain market for a certain year, that they may be readily comprehended and market standards compared. Assuming that the trade organization of a market adopts fixed limits for the grades recognized by it and publishes these limits in the ordinary rules for grades, these rules could be shown in a tabular statement something like the following:

## DENT CORN.

Three classes:

1. Yellow corn; at least 95 per cent yellow.
2. White corn; at least 98 per cent white.
3. Mixed corn; all corn not included above.

## YELLOW CORN.

Grade No.	Maximum limits of—			
	Per cent of moisture.		Per cent damaged.	Per cent of dirt and broken grains.
	Nov.-Mar.	Apr.-Oct.		
1.....	13	12	0	0
2.....	15	14	1	2
3.....	17	16	3	3
4.....	19	18	6	5

A similar table might be made for each of the other classes of corn, providing different percentages were used.

It should be distinctly understood that the grade limits in the above table are given merely for the purpose of illustrating its use. Just what these standards should be must be determined to suit local conditions or to suit the requirements of each market or series of markets handling the same sort of grain, and they could be changed from year to year as occasion required.

### INSPECTION CERTIFICATES.

It is difficult to fix the grade limitations in a way to do full justice to all cargoes graded. Were it possible to assign definite relative values to each measured element a score card could be made by which the cargoes could be rated, but the variety of uses to which any grain is put, results in a sliding scale of relative values, which renders the use of a general score card impossible. Definite grade limitations are absolutely necessary to secure uniform results. To compensate to some extent the injustice sometimes done by drawing sharp grade lines, it would seem desirable to have the inspection certificates show something more than the grade actually given to any cargo of grain.

Such a certificate could show, in addition to the class and grade number of the cargo, its approximate condition as to moisture, damaged grain, broken grains, and, in case of mixture, the proportion of the colors present. A certificate of this kind would enable the prospective purchaser to select, in buying cargoes of grain, those which he could mix to advantage to secure certain results, or a seller might use such a certificate in placing his grain to advantage with customers having particular needs or special facilities for remedying certain defects. These certificates would in no way interfere with the maintenance of the present contract grades and might be of considerable assistance in dispensing with sample dealing.

### THE CAUSE OF DETERIORATION.

With the exception of the rather infrequent cases of insect damage of one sort or another, the one cause of the deterioration of corn in transit and storage in this country is excessive moisture.

Corn matures so late in the season over most of the area that produces a surplus, that there is not sufficient warm, dry weather to properly cure it, and the bulk of the crop usually goes into the crib damp and cold.

If it is shelled in this condition and put into store in large bins the grain has almost no opportunity to dry out properly. As long as the cold weather lasts the damage is slight, unless fermentation is accidentally started or the grain is unusually damp, but with the warm weather of spring the trouble begins. In the commercial world this trying time is known as the "germinating season." As a matter of fact, there is little or no actual germination of the stored corn at this

time. It rarely develops as far as that. Some fermentative action takes place, equivalent to the preliminary stages of germination, but this usually results in stored grain in the development of sufficient heat to kill the germ.

Under ordinary conditions corn containing not more than 12 to 13 per cent of moisture at the beginning of the warm weather following its maturity will carry or store safely, but new corn, that is, corn soon after maturity, frequently contains 20 to 22 per cent of moisture, and if not given opportunity to dry out during the winter, trouble will result when warm weather comes and induces fermentation.

When corn is left on the cob until the late winter or spring following its maturity, and is stored meanwhile in well-ventilated cribs, it will in most cases dry out sufficiently. But where earlier marketing is necessary other ways of curing must be had if the corn is to be carried safely through the spring season.

There are three things essential to germination or the fermentation which precedes it—air, warmth, and moisture. Without all of these it can not go on.

The moisture is the one of these easiest to control or to remove when it is present in dangerous excess. Therefore when the temperature is nearing the line where the other two elements may result in damage the moisture must be removed. Modern grain storehouses are so constructed that grain may be moved from one bin to another by means of transfer belts and elevators and given a chance to air dry during the moving process. This process is called "running," and is frequently used to keep grain from going out of condition.

In the case of corn, however, this treatment if used too frequently results in breaking many of the kernels and, therefore, damaging the lot to some extent; and the operation is also somewhat expensive where large quantities must be so treated. Within recent years commercial driers of one sort or another have been installed in some of the large warehouses. These driers all depend on the same principle—that is, that an increase in temperature increases the water-holding capacity of the air. In all of them heated air is passed through the corn until the superfluous moisture is removed. This process is known as kiln drying. It is in disfavor with some persons in the trade, who claim that the heat injures the corn for manufacturing purposes, and, further, that the damage by cracking and breaking in subsequent handling of kiln-dried corn is considerable.

There is apparently good reason for some of the disfavor in which the general practice is held, because there has been a tendency on the part of the managers of these driers to work on badly damaged lots of grain and mix the product with better grades.

So far as may be determined at present, the drying of corn at a moderate temperature can be only a beneficial operation. If for



certain purposes of manufacture the high temperatures ordinarily used have harmful results, it is quite practicable to use lower temperatures for longer periods or to carry the principle already used still farther and cool the air used for drying to a low temperature to precipitate the excess of moisture it contains and subsequently warm it up enough to make it absorb the excess moisture of the corn.

However it may be done, it is evident that artificial drying of some kind will inevitably be more generally used to prevent the enormous losses now resulting from the excess moisture in corn.

### LOCAL AND SPECIAL GRADES.

The development of commercial driers for corn and the specialization in manufacturing cereal products suggests the advisability of keeping in view the possible establishment of additional grades for local and special purposes as needs for them arise. This is particularly important in view of the remarkable work which has been done in improving varieties of corn, not only in increasing the yield per acre, but also in improving the quality; in other words, increasing the percentage of certain desirable constituents. The work that has been done in breeding varieties of corn which have a high percentage of oil and others with a low percentage of oil, and varieties with a high percentage of protein, and others with a high percentage of starch, which means a low percentage of protein, calls attention to the fact that it should be possible for the growers of these improved varieties to get them to those consumers who are willing to pay prices above the ordinary for these extraordinary qualities. It should be the function of the grain inspector to be able to recognize these special classes and to grade the grain accordingly.

It has been shown by Professor Hopkins, of the University of Illinois, that it is possible to judge by observation with reasonable accuracy the merits of different lots of corn as to the amount of protein and oil which they contain. He has shown that, since the oil of corn is found almost entirely in the germ, the relative size of the germ gives a fair indication of the oil content of the grain. Likewise in the matter of protein content, the hard portion of the corn kernel, that is, the somewhat translucent portion outside the germ, contains practically all the protein except the small amount in the germ. Therefore, the larger the proportion of this hard part of the corn kernel the larger the percentage of protein and consequently the smaller the percentage of starch. Manufacturers of corn grits and meal, where a granular product is desired, find that there is considerable variation in the relative yields of these products from different sorts of corn.

In Pl. III is shown the striking difference that may be seen in different kernels of corn as to the proportion of the hard and starchy

portions of the grain. Other things being equal, the yield of grits or granular meal is larger from corn having the larger proportion of this hard material.

Corn breeders and progressive farmers are rapidly appreciating the importance of breeding special varieties of corn for special purposes, and it is probable that in the near future certain varieties of corn from certain localities will be quite as distinctly recognized as being rich in specific merchantable qualities as is now the case in such varieties of wheat as the Fife, the Little May, or the Mediterranean. This will naturally lead to a more logical classification of commercial corn on the basis of varieties or groups of similar varieties, and these classes may then be divided into grades, as at present. Such a classification would in no way conflict with the present methods of commercial dealing, since the trade organization of a market could determine what grades could be delivered on contract just as is done at present.

The greatest need of the grain trade now, however, is the installation of an accurate method of determining grades in all cases of doubt and for the education of the judgment of the grain inspectors and the consequent uniformity of the work of inspection departments.

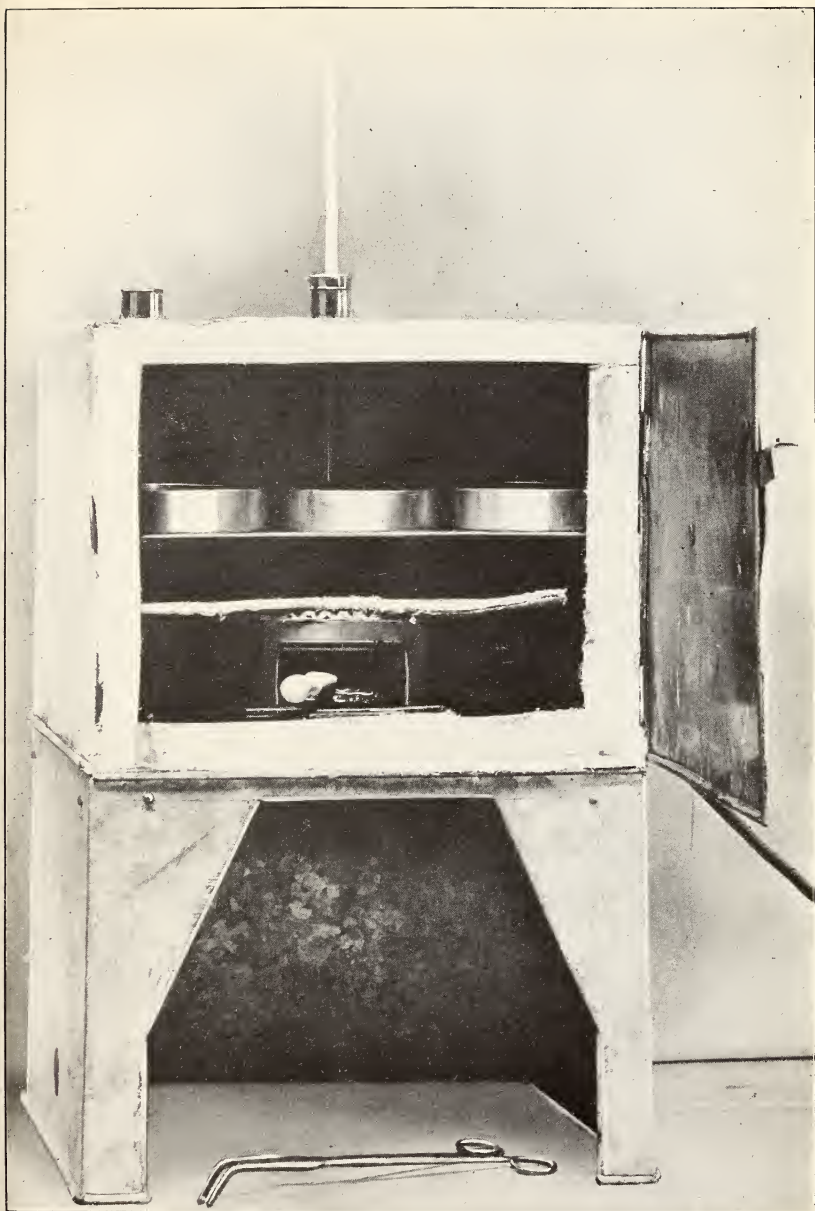
## DESCRIPTION OF PLATES.

PLATE I. Air-bath used for determining the amount of moisture in a sample of corn, with aluminum pans and electric heater inside. A piece of asbestos is placed over the heater to distribute the heat more evenly to the pans. The forceps shown below are for transferring the pans to and from the bath to avoid the possible error consequent on touching them with moist hands.

PLATE II. Fig. 1.—Mill for grinding corn samples, with extra set of burrs and brush for cleaning mill after each grinding. This mill may be clamped to the edge of a table and is simple and strong. It may be easily taken apart for cleaning or changing the burrs. Fig. 2.—Balance used for weighing corn samples. This balance is surrounded by a metal frame set with plate glass, and is provided with a sliding weight on a fixed scale, so that the weighing may be done rapidly.

PLATE III. Kernels of corn shown in longitudinal and cross section. Magnified six times. These kernels show rather extreme variations in texture. The two kernels at the left of the picture show a high proportion of the hard or translucent substance of the kernel outside the germ, which has been shown by Professor Hopkins, of the Illinois State Experiment Station, to be directly correlated with high protein content. The kernels on the right show a relatively small amount of this hard substance, and are consequently of the type which is low in protein and therefore rich in starch. For processes of manufacture of corn where a granular product is desired the type of corn shown on the left is much preferred, while for starch manufacture the type shown on the right of the picture is more desirable. In the same way the relative size of the germ of the corn kernel indicates the percentage of oil contained, since practically all the oil of the corn kernel is found in the germ.

PLATE IV. Kernels of corn showing various kinds of damage, and sound kernels shown for comparison. Twice natural size. The upper three rows are of kernels showing the various mold growths commonly found on damaged corn. These molds develop only on excessively moist corn and are much more likely to occur when there is a deposit of fine meal or dirt in the germ indentation. This deposit offers a good culture medium for the development of the molds, and in a majority of cases the damage starts at that point. Perfectly clean corn will carry or store much more safely than dirty corn having the same amount of moisture.



AIR-BATH USED FOR DETERMINING THE AMOUNT OF MOISTURE IN A SAMPLE OF CORN.







FIG. 1.—MILL FOR GRINDING CORN SAMPLES.

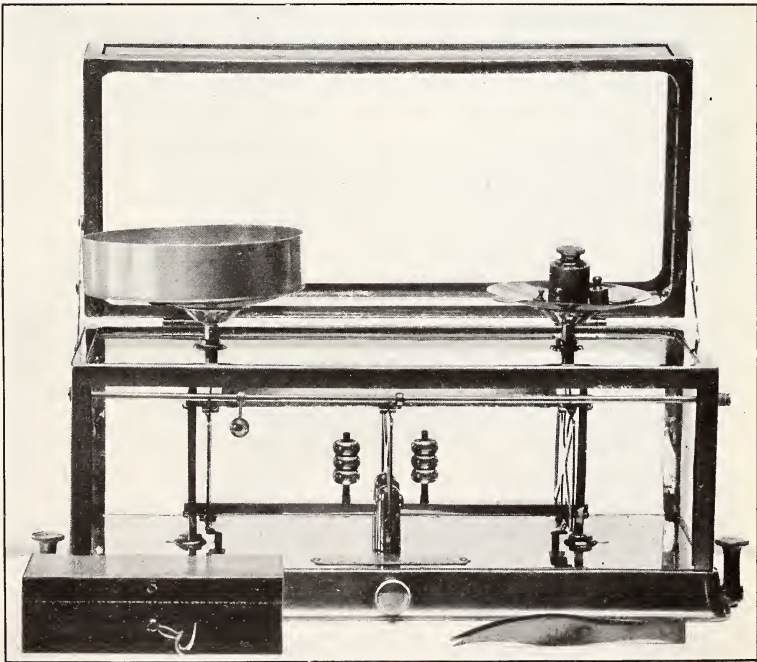
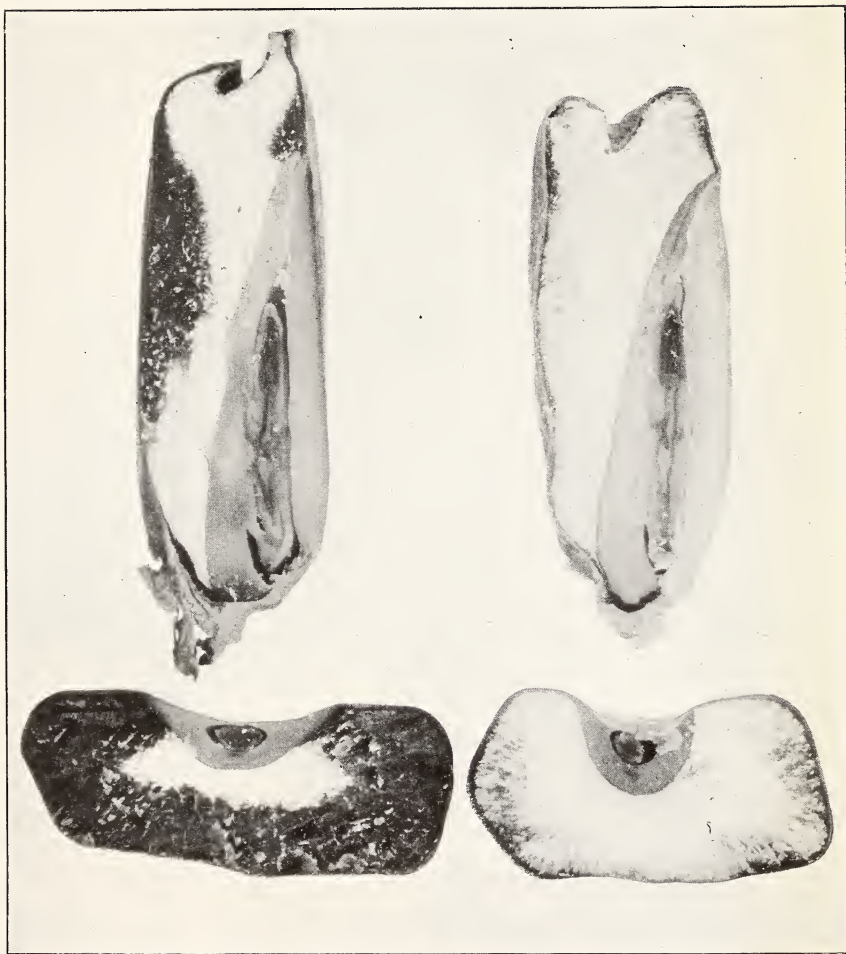


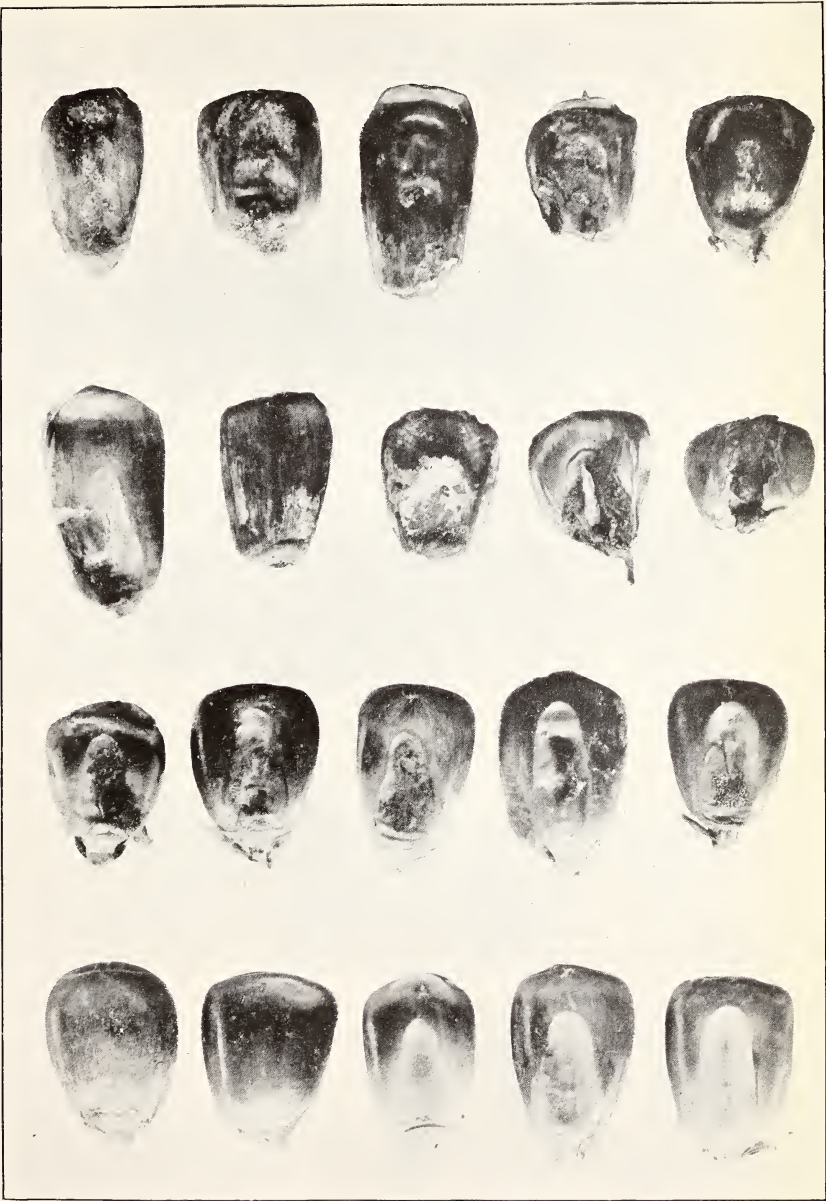
FIG. 2.—BALANCE USED FOR WEIGHING CORN SAMPLES.





KERNELS OF CORN, SHOWN IN LONGITUDINAL AND CROSS SECTIONS.





KERNELS OF CORN, SHOWING VARIOUS KINDS OF DAMAGE.

